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INSTRUCTION IN AN IMPERFECT SCIENCE

Challenges in Defining – and Teaching – Technology around 1800

Jocelyn Holland

The concerns that arise over the use of technology in the classroom – what kind of technology to use, how frequently, and in what manner it should be integrated – are some of the most pressing pedagogical questions today. Those participating in this debate might be surprised to hear that intellectuals and self-described "technologues" around 1800 also considered the challenges of integrating technology into university curricula. People who were thinking and writing about technology around 1800 faced a problem which still haunts us today: how to define the object of study in the first place. As Carl Mitcham and Eric Schatzberg have argued, the term technology and the field of study encompassed by the "technological sciences" are "loaded with contested connotations and interpretations, in part because definition and associated conceptualization has implications for other issues, such as the relations between technology, science, and art." [1]

Around 1800, as today, the question of technology in the classroom went well beyond the study and use of technological objects. The instruction of technology was also attuned to the concepts used to define the technological status of these objects in the first place as well as to the question of what a "science" of technology might be. In the German context, which is the focus of the present essay, the word itself was still a neologism. In the 1770s, Johann Beckmann claimed to do something new by deliberately replacing a term he considered obsolete, *Kunstgeschichte* (which referred a history of the "arts" in the broadest sense), with *Technologie*. [2] The situation is, however, somewhat more complex than Beckmann would have us

believe: not only was the German word *Technologie* already used in various ways prior to Beckmann, the semantic and discursive histories of *Technologie* throughout the eighteenth century are overshadowed by the growing awareness that it is, in fact, quite difficult to define its scope. When the question of technology as a subject for the classroom garnered attention toward the end of the eighteenth century, it also provoked the basic question of how best to systematically teach an imperfect science.

These issues connect directly to the nascent theoretical reflections on technology as a word, concept, science, and academic discipline in the German context of the long eighteenth century, well before anything resembling a "philosophy of technology" was established. The present essay, connected to a larger research and translation project devoted to eighteenth-century perspectives on technology, does not intend to make an exhaustive historical argument, but rather to introduce readers to a few of the key players of the time period and to sketch out a narrative that connects the question of technology as it was framed at that time with the problem of how to teach it. These remarks, which can be seen as making a small contribution to a complicated puzzle, will focus primarily on two general topics: how Beckmann's "translation" of technology in the 1770s connects to its development as an imperfect science around 1800, and the problems – as well as opportunities – that emerged when technology was considered for the classroom. An additional aim, apart from commenting on the epistemological problems surrounding the history of technology during this time period, is to show that one of the most peculiar products of these technological discussions is the imagining of a special kind of observer: one invested with critical skills and the authority to make a kind of "mechanical judgement" with regard to objects and the science of technology as a whole.

From a Translated Word to an Imperfect Science

As a German word, *Technologie* is in the eighteenth century most frequently associated with Cameralism, an economic term that emerged in seventeenth-century German principalities, and whose primary concerns were "directed to the state's interest in its resources, in better administration and in the common good, the purpose being in order to increase the prince's incomes, establish a sustainable development of economy, and create a well-ordered state." [3] Beckmann writes in the preface to the first edition of his *Instruction Book for Technology* [*Anleitung zur Technologie*] that "the knowledge of handcrafts, factories and manufactured goods is

indispensable to everyone who wishes to dedicate himself to statecraft and the science of cameralism." [4] The administrators-in-training of the German principalities were supposed to have a good working knowledge of both the liberal and the illiberal arts. Yet Cameralism was only the latest resting point of a long discursive migration of the word "technology" since antiquity. For the Greeks, the cognate word referred to a systematic treatment of something, such as a grammar, [5] which is also the sense in which Cicero borrowed it for Latin: one can think of his *de Oratore* as a technology of rhetorical technique. The defining element of technology as it is used in this earlier sense is a collection of rules designed for application. One still finds the understanding of technology as a collection of rules through the seventeenth century, where its application was expanded to include other areas of study, such as theology; Gaspard Streso's 1633 *Technologia Theologica*, for example, applied rules of logical analysis to theological tenets. As far as the German context is concerned, Christian Wolff provides a good point of reference for understanding the early-eighteenth century discussion on technology at the cusp of Latin and German as the scholarly language of choice. In his *Philosophia rationalis sive logica* (1728), Wolff offers this simple, yet programmatic definition:

> It is also possible to have a philosophy of arts, even if this has been hitherto neglected. You can call it technics [*technica*] or technology [*technologia*]. Therefore, technology is the knowledge [*sciencia*] of arts and of works of art, or, if you prefer, the knowledge of those works which are completed by men with the instruments of their body, especially the hands. [6]

Seibicke has argued that "with this special use of both expressions [*technica* and *technologia*]," Wolff has laid "the basis for the development of the concept of technology [*des Technikbegriffs*] so important for modernity," and that one can see this as the first step in the "program of a systematic science of technology [*Technikwissenschaft*]." [7] Certainly, several aspects of Wolff's definition bear directly on later eighteenth-century usage: first, technology is primarily understood as a theoretical enterprise, one that deals both with the knowledge (or science) of the arts and with the products of that knowledge – the works of art themselves. "Art," in this context, is understood in the broad sense of man-made things before being specified to works of the hand, but otherwise makes no distinction between the fine and banausic arts. Secondly, this definition articulates an important point of bifurcation. Wolff offers a choice between *technica* and *technologia* – as if to say that

we could conceivably have a philosophy of arts without the “logos” which comprises scientific discourse – before leaning towards the latter. Over time, the distinction between technics and technology takes different forms, including the immediacy of social practices vs. the ideas which encompass them. [8]

Some idea of a technology is therefore already active in the German context when Johann Beckmann writes, in the fourth edition to his Instruction Book, “I first dared in 1772 to use technology [*Technologie*] instead of the customary designation history of arts [*Kunstgeschichte*], which is at least as incorrect as the designation history of nature [*Naturgeschichte*] for the theory of nature [*Naturkunde*].” [9] A few of Beckmann’s contemporaries, such as Daniel Heinrich Bensen, professor of Cameral Sciences in Erlangen in the 1790s, found Beckmann’s statement problematic: “Why does one not prefer, if one is in agreement on the general concept of a handicraft [*Handwerk*], to use the German word *Handwerkskunde* [study of handcrafts] which simply and precisely expresses the exact same thing?” [10] Later historians, including Seibicke, claim with hindsight that Beckmann’s Instruction Book “marks the change from the quantity of techn(olog)ical knowledge into the new quality of a techn(olog)ical science.” [11] Such disputes aside, Beckmann does go at least a step farther than Wolff’s notion of a “science of arts and works of art” when he articulates the distinction between *Technologie* and *Kunstgeschichte*; according to Beckmann, a history of art (or the arts in general) might describe the invention and fate of a particular craft, but “technology is something which explains, in an orderly manner, and which establishes the foundation and logical consequence of all kinds of works [*Arbeiten*].” [12] The tension inherent in the eighteenth-century discussion on technology does not just emerge as a distinction between Wolff’s and Beckmann’s approaches, however. There is also a third source to bring into this conversation, one which stands for another problem inherent in the emerging reflections on technology: Johann Zedler’s *Universal Lexicon*.

The significance in Beckmann’s act of translation has less to do with a linguistic transferal that exports technology among languages than a translation from one way of identifying a field of thought to another. By contrast, the definition of *Technologie* in Johann Zedler’s lexicon – a massive, sixty-eight volume project published between 1731 and 1754 – is based on words. For Zedler, technology is synonymous with *Kunst-Wörter-Lehre*. As a doctrine of *Kunstwörter* (where a *Kunstwort* is understood as a *terminus technicus* or technical term), technology becomes a way of organizing things that belong to people of a particular profession. Along these lines, a carpenter

will have specific words for his tools and techniques, as will all other craftsman. To the degree that Zedler's definition of "technology" suggests a collection of these words, it is situated in the classical rhetorical tradition of Cicero. Yet even if Zedler's definition is clear enough, the question of what it denotes poses a problem for the German language. The technical terms of the different arts often required mastery of Latin, which led to the common practice translating the technical terms into German somewhat arbitrarily, "without the approval of others" so as to "cause obscurity." [13] In other words, based on Zedler's lexicon, it is clear that the early translation of technology as a concept from Latin to German carries with it the problem of translation in general – at least as a problem of the parts (i.e., the technical terms), if not yet the whole.

Against the backdrop of Wolff and Zedler, Beckmann's own "translation" of technology therefore takes a different shape altogether, beginning with a re-definition of his point of departure. Because Beckmann understands himself as departing from a history of the arts, he requires a theoretical apparatus, something closer to a science. This idea is fundamental to the definition of technology found in his *Instruction Book*, where he writes that "technology is the science [*Wissenschaft*] which teaches the processing of things made by nature … the knowledge of handcrafts. [14] What Beckmann has in mind is inspired as much by a "philosophy of the arts" as it is to by Zedler's understanding of technology in terms of a theory of technical terms, albeit with a few key differences. Having established in not-too-specific language that technology is a science that handles potentially everything in nature, a second part of the definition goes a step further to define the place of the discourse of technology in society in contradistinction to the physical place of the workshop:

> Instead of being shown in the workshops, how one should follow the directives and customs of the master, technology gives thorough instruction, with systematic order, how one should, for the same purpose, find the means, drawn from true principles and reliable experience, and how one should explain and use those phenomena which appear during processing. [15]

If technology, according to Beckmann, can act in the stead of the master craftsman who gives instructions in the workshop in that it provides a "systematic order" and "thorough directions" based upon both principles and practice, then it is more than a

theoretical science. Beckmann's technological project implies a collapse of both discursive and spatial distinctions: that is, the difference between theory and practice, as well as the difference between the work (and place) of the scholar and that of the craftsman. And although Beckmann wants to establish his "technology" in a trajectory apart from Zedler's by claiming it as a science whose system achieves validity to the degree that it is not taking part in a history, he must nonetheless confront the technology of words as posed by Zedler by re-scripting the space of the workshop, with its profusion of technical terms, its clash of vernaculars. Through Beckmann's imagined projection into the space of the workshop, two technologies – the one, a science of arts and the other, a theory of words – become deeply intertwined.

To illustrate the connection between technological lexica and systems of technology more clearly, and to underscore the problems of both as pedagogical topics, I am going to draw briefly on two examples, the first from Beckmann's preface to Jacobsson's "Technological Dictionary" (1781-84) and the second from Georg Friedrich Lamprecht's *Lehrbuch der Technologie* [*Textbook of Technology*] (1787). [16] With regard to the former: Beckmann writes that what one can expect to find in a technological dictionary such as Jacobsson's is not just the technical terms that refer to the methods of production unique to the various arts, but also those words which refer to materials used by artisans, different kinds of crafts, and the wares produced by them. Much of Beckmann's admiration for Jacobsson comes from the enormity of this task, whose difficulty is only increased by the number of synonyms and dialect words for any given term; the number of crafts alone is "so large, that it is difficult only to compile a complete index of them" not to mention the tools and materials unique to each. [17] The comparison which Beckmann draws from throughout the preface to the dictionary, and which dates back to his earlier work, is with the study of nature. Already in the *Instruction Book* he invoked the name of Charles Linné, the eighteenth-century botanist renowned for generating a descriptive technical language to conform to his far-ranging observations of natural phenomena. [18] The proliferation of crafts and the words of human artifice is second only to the number of phenomena in the natural world. Yet the analogy is not only between two scientific discourses of comparable enormity. Beckmann's preface also insists that in order to understand the multitude of words drawn from the most various kinds of crafts, we also need at our disposal a set of auxiliary sciences [*Hülfswissenschaften*] in addition to the theory of nature, including mineralogy, chemistry, metallurgy, and mathematics. [19] Which is to say that the "parts" of technology, in addition to being

a collection of words, are also a collection of mutually implicated discourses and disciplines.

One can compare the challenges posed by genre of the technological dictionary as described by Beckmann with the system proposed by Lamprecht's *Textbook of Technology*. For Lamprecht, the function of technology as a science is largely pedagogical: it teaches the principles and means by which those products of nature that would otherwise not be useful to man can be made into useful things. Because technology teaches the manifold ways of processing nature for human advantage, it must, according to Lamprecht, necessarily include a theory of the arts. The problem with his plan, Lamprecht soon realizes, is simply the inordinate number of them. In this regard, the challenge of the technological dictionary is analogous to that of the technological treatise: both must subsume a manifold in the name of technology. Whereas one deals with words, the other deals with the discourses of the arts in the broadest sense. In each case, the line between the categories of the technological vs. the non-technological is difficult to define.

Informing Lamprecht's treatise is a series of attempts to define a theoretical basis for technology in such a way as to clarify the distinction between technology and other discourses. Yet each of these is met by failure. For example, Lamprecht cannot exclude the fine arts for obeying rules of taste and beauty, because the same can be said of some of the mechanical arts as well, such as the production of jewelry or fine watches; from this perspective, "aesthetics" could never establish itself as an autonomous discourse, as was the tendency in the eighteenth century, and Lamprecht even goes so far as to refer to it as an auxiliary science (see §12), just as Beckmann does of botany, chemistry, and the rest. Similar attempts to define technology's theoretical basis – such as drawing on traditional distinctions between theoretical and practical arts, or productive and non-productive ones in the Aristotelian sense; or even through distinctions based on technique, on product, or use – meet with just as little success. Lamprecht's only recourse is to devise a strategy that has more to do with the concept of numerical frequency than with principles of inclusion and exclusion: "Error-free divisions and completely logical concepts of the separate parts of technology seem after all attempts, because of the countless number of entirely different objects, to [that] belong to the category of impossible things." [20] Lamprecht continues by suggesting that the order of a technological system is simplified by beginning with explanations of those techniques for dealing with nature which apply to the majority of crafts, and continuing with the

more specific – in other words, through distinctions that hold up quantitatively, rather than qualitatively.

Even if it is clear by now that the vast scope of the arts, coupled by an inadequate theoretical grounding, hinders technology's systematic cohesion, it is important to ask the question, what kind of knowledge was treated in a technological instruction manual. The question bears directly upon the pedagogical challenges of technology that will be addressed in the second section of this essay. In Beckmann's Instruction Book, for example, some chapters contain their own taxonomies of the kind of knowledge required for an adequate understanding of technology. One can consider this passage from the chapter on numismatics, whose description echoes the problems of the technological project as a whole:

> The science of coining [*Münzwissenschaft*] is the name of the system of all knowledge which have been given rise to and made necessary by coins [*Münze*]. A science of inconceivable extent! Its noblest parts seem to me to be the following.
>
> 1. The technological part or the art of coins [*Münzkunst*], which teaches the preparation of coins.
>
> 2. The historical part, which deals with the origin of money and coins, and their various changes.
>
> 3. The antiquarian part, which teaches the knowledge of old, no longer circulating coins, and which until now has been dealt with under the name numismatics [Numismatic].
>
> 4. The mercantilist part, which teaches the intrinsic and extrinsic worth of coins in circulation and their relation to each other.
>
> 5. The political part, which contains that which, where currency is concerned, is to be observed with regard to public affairs. ~~[21]~~

Of note in this entry is that the "technological" per se is only one part of the "technology" of numismatics. Adequate training in this field requires more than

knowledge of how coins are produced: it also requires an understanding of how they are traded and how their past and present value is determined, both in intrinsic terms and for society as a whole.

Other entries in Beckmann's *Instruction Book* foreground the material factors of production more clearly. The chapter on hat-making, to take just one example, is divided into seven paragraphs: an introductory statement on the materials, where they are found, which ones are most valuable, as well as the basic method of production (for example, that hats are 'felted' instead of woven); a paragraph on the preparation of animal hair; an explanation of how the hair is sorted; the processing of the felt pieces or Fache; techniques of Walken, whereby felt is manipulated into a circle shape; how the felt is smoothed with pumice and fish skin before dyeing; and the washing and drying of hats after dyeing. [22] What kind of knowledge do these paragraphs impart? What should a reader – or student – of technology be able to do after working through this chapter? Reading about hat-making does not directly impart the manual dexterity required to be a hat-maker, but it does impart the elements of what can be developed into techniques of discrimination relevant to the process. What can be acquired through reading are such factors as an appreciation for the quality of materials, the evenness of the felt, the richness of color, and the shape of the hat. In short, most of what one needs in order to determine the greater or lesser perfection of the technological product is contained in these paragraphs.

Teaching Technology and Technological Observation

The example of hat-making describes an environment where local acts of discernment and discrimination are necessary, actions that can be generalized to the science as a whole. Like an aesthetically-trained observer of a work of art, the technologue is one who tries to intuit order from a sensory manifold. Unlike the observer of a work of art, however, the technologue's sense of the manifold entails significantly greater degrees of complexity. Instead of one single system of parts to whole, multiple such relationships of parts to whole inhabit the technologue's gaze. These include the relationships of technology to the "arts" in general; various kinds of knowledge encompassed by a single "art," and knowledge of either the machines or tool-use – which also demands a kind of synthetic understanding of individual parts or actions – included in a component activity of a particular art.

The implied connection between science, aesthetics, and technology is firmly in place by the end of the eighteenth century. It had already been suggested by the Italian economist-philosopher Antonio Genovesi (1713-1769), whose *Lezioni di Commercio o sia d'Economia civile* (1764) was translated into German as the *Gründsätze der bürgerlichen Oekonomie* [*Principles of the Bourgeois Economy*]. [23] The pinnacle of culture, writes Genovesi, is defined by the "blooming" of the (technological) arts and is matched by achievements in literature and science, because together they not only expand mankind's understanding, they "enlighten him, and show him in the most insignificant professions that which he would otherwise not see." [24] A footnote is attached: "Every art, however insignificant it may be, has its principles, and its mechanism, which only the philosopher can perceive. Thus the theories of the lowest arts be brought into a science. This proves the necessity of calculation and of a reasoned mechanics [*meccanica ragionata*]." [25]

Embedded within this passage from Genovesi are the elements of what will eventually be developed into a pedagogical program based on the joint assumptions that it is instructive to observe the techniques and materials used by practitioners of the mechanical arts and that the rational observer is in the position to improve upon them. [26] Genovesi was also important for German technologues, such as Beckmann, who uses the quote as an epigraph to his *Instruction Book*, as well as for the lesser-known Franz Benedikt Herrmann, who was, at the end of the eighteenth century, a central figure in the development of a technologically-informed pedagogy. Hermann's guide to learning technology, *Über die Einführung des Studiums der Technologie* [*On the Introduction to the Study of Technology*], picks up on the same passage from Genovesi, but misquotes it in a peculiar way, one that reveals something about his

own agenda. It is instructive to compare the 1776 German edition of Genovesi's text with the equivalent passage in Hermann's in order to see the differences as to how they are rendered into German:

> "Jede Kunst, so gering sie auch sey, hat ihre Grundsätze, und ihren Mechanismus, denbblos der Philosoph wahrnehmen kann."
>
> [Every art, however insignificant it might be, has its principles, and its mechanism, that only the philosopher can perceive] (English version Genovesi's German translation by August Witzmann) [27]
>
> "Jede Kunst, so gering sie auch ist, hat ihren eigenthümlichen Mechanismum, und ihre Grundsätze, welche nur von Philosophen erklärt werden können"
>
> [Every art, however insignificant it is, has its unique mechanism, and its principles, which can only be explained by philosphers] (English version of Genovesi's German translation by Benedikt Hermann) [28]

Genovesi's philosopher-observer perceives the principles of the mechanical arts (which is also faithful to the original Italian, *esser avvertigto*), whereas Herrmann's is the one who is able to take the extra step of transforming perceptions into explanations. This kind of philosophical work, he argues elsewhere in the same treatise, stands in sharp distinction to the "uselessness" of traditional metaphysical speculations.

Herrmann's own working definition of technology understands it as a synthesis of observation and discrimination. In a kind of circular thinking peculiar to the science of technology, Herrmann emphasizes science itself "shows" the observer precisely those things which are organized under the heading of a science of technology. For example, it shows:

> …from which material, and how our articles of clothing are made; what we have to observe, in order to distinguish the good wares from the bad, and how we have to arrange to improve what is bad or faulty. [29]

> …wherefrom those materials must be taken, which we have need of for the establishment of our dwellings… [and] thereby teaches, which are the best, how they must be processed, arranged, applied and maintained. [30]

Technology is nothing less than a world view that "must," according to Hermann and others, be treated as a science that can be imparted to others. Part of the motivation is regional competition: France, for example, is perceived of as being ahead of the German territories both in the teaching and practice of technology (the subject of §10), even though the French language had at that time not yet adopted the word technology in the Beckmannian sense, nor generated an equivalent theoretical reflection on *la technologie*.

With these challenges in mind, Herrmann devotes considerable energy to the problem of technological instruction. After identifying several requirements, such as visiting workshops, purchasing books, and the establishment of state schools, he reflects upon the challenges associated with each. In part, it is a question of class prejudice: "Wealthy youth," he writes, "have no desire to study technology" and "the poorest cannot travel to visit workshops and will not receive permission to enter local workshops and factories." [31] There is also the risk that, once admitted, workers will have no desire to reveal trade secrets. [32] An additional problem concerns the technological books themselves: "young people reading these books will not understand the vocabulary" because "they have no familiarity with the objects," [33] not to mention the fact that these books, with their numerous illustrations, were for poorer students prohibitively expensive.

The fields necessary for the education of future technologues, which include agriculture, knowledge of the technical arts (*Kunstwirtschaft*), the study of private trade (*Privathandlungswissenschaft*), technological chemistry, engineering (including hydraulic engineering), and veterinary arts, are not yet widely taught at university. For Herrmann, at least, all of these factors point to the need to establish public schools: "A talented teacher, a good textbook, and a collection of tools, materials, and wares can also, in my opinion, most reliably educate a technologue as useful for the state as advantageous to oneself." [34] Herrmann also drafts a preliminary teaching program, which should, among other things: demonstrate the use of technology for the state, say something about the history of a particular trade or art, discuss materials, explain the processes involved with tool usage and describe the

tools themselves, teach students how to discriminate between good and bad products as well as areas of improvement, consider the conditions for introducing a new trade to a new country, and, last but not least, explain the use of the products in life. Teachers who intend to accomplish these goals, he muses, must necessarily have a collection of models, machines, drawings, and “technical products” (*Kunstprodukten*) at their disposal.

Taken together, the technological agendas of Beckmann, Lamprecht, and Herrmann cannot represent the entire complexity of the discussion about the problem of technology and its instruction around 1800, but their contributions give a sense of the varied perspectives on technology at that time and provide a point of departure for further thinking and comparison. From today’s point of view, it is equally instructive to observe to what degree these three thinkers differ as well as ways in which common concerns emerge. Much of this has to do with an awareness of limits, in both practical and philosophical terms.With regard to the latter: it should be clear by now that, theoretically speaking, technology is difficult to contain. Its objects and practices are so interwoven with other arts and sciences that it resists any attempts at tidy packaging. With regard to the former – the “practical” limits of technology – we can see that the problem Herrmann articulates as a matter of education can also be articulated in more general terms as a problem of knowledge transmission. His concern is equally with the material restrictions of class, i.e. the access to technological objects, and with the challenges of instruction: learning “about” the technical arts is by no means the same as learning the arts themselves. Young students of technology find themselves in a much different position than the first generation of self-proclaimed technologues: each judges the state of technology and the technological arts differently. Students of technology are not burdened by such questions such as Lamprecht’s, however – theirs is not the problem of creating a scientific system. Instead, as Herrmann emphasizes, their training is one of the technological gaze: one which begins by discerning and discriminating across materials, tools, and scales before becoming concerned with pursuing the chimera of a systematic whole. To perform acts of reasoned judgement in the classroom, in the workshop, and in the factories: this is the goal of a training that Herrmann predicts will be facilitated through progress in the public school system, a trajectory that will ultimately bypass the cumbersome, incomplete, and ultimately unviable technological systems altogether.

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1. Carl Mitcham and Eric Schatzberg, “Defining Technology and the Engineering Sciences” in *Handbook of the Philosophy of Science*, vol. 9, Anthonie Meijers ed. 2009 Elsevier, 27-64; 27. ↩

2. For recent work in this area, see Eric Schatzberg’s *Technology: Critical History of a Concept*. ↩

3. Marten Seppel, “Cameralism in Practice,” 1. Seppel notes that cameralism was “first and foremost a way of thinking and a common language (*rhetori*),” and that there is “little consensus over the specific and definite character of ‘cameralism’” (Seppel, “Cameralism in Practice, 5-6). Tribe also underscores the notion of Cameralism as a doctrine of teaching, recorded in books for academic use when he writes that “Cameralism was a form of academic pedagogy” and that “[a]s a written discourse it was embodied in the several hundred textbooks produced for use by students in German, Austrian, and Baltic universities between the 1720s and the 1790s” (Tribe, “Cameralism and the Sciences of the State,” 525. ↩

4. Johann Beckmann, preface to the first edition, in *Anleitung zur Technologie: oder zur Kentniß der Handwerke, Fabriken und Manufacturen vornehmlich derer, die mit der Landwirthschaft, Polizey und Cameralwissenschaft in nächster Verbindung stehn* (Göttingen: Wittwe Vandenhoeck, 1780), unnumbered page. ↩

5. Liddell and Scott, *A Greek-English Lexicon*, “τεχνολογ-ία.” For a more exhaustive discussion of technology’s early history see Wilfried Seibicke’s book, *Technik. Versuch einer Geschichte der Wortfamilie [techne] in Deutschland vom 16. Jahrhundert bis etwa 1830*. One of Seibicke’s many contributions is to problematize the priority of technology’s two key semantic components by pointing out that various historical time periods have witnessed the predominance of a “logos der techne” as opposed to a “techne des logos” (Seibicke, *Technik*, 97). ↩

6. philosophia rationalis sive logica, 2nd edition (Frankfurt and Leipzig: Renger, 1732), 33. ↩

7. Seibicke, “Von Christian Wolff zu Johann Beckmann,” 43. ↩

8. Carl Mitcham, *Thinking through technology: the path between engineering and philosophy*, (276). ↩

9. Beckmann, *Anleitung zur Technologie*, 4th edition (Göttingen: Vandenhoeck and Ruprecht, 1796), 20. ↩

10. Bensen, *Versuch eines systematischen Grundrisses der reinen und angewandten Staatslehre für Kameralisten*, 204. ↩

11. Seibicke, “Von Christian Wolff zu Johann Beckmann,” 47. ↩

12. Seibicke, “Von Christian Wolff zu Johann Beckmann,” 47. ↩

13. Johann Zedler, s. v. “Technologie.” ↩

14. Beckmann, *Anleitung* 4th ed., 19. Readers should keep in mind that Beckmann’s understanding of *Wissenschaft* as “science” is not quite the same as ours, but rather closer to the definition one can find in Adelung’s historical dictionary, where *Wissenschaft* is distinguished from *Kunst* in that the former contains general truths “of a particular kind” linked to one another and the latter contains mere propositions of practice [*Ausübungssätze*]. See Adelung, “Wissenschaft,” in his *Historical-Critical Dictionary*, part 4, from Seb to Z, col. 1582. ↩

15. Adelung, “Wissenschaft,” in his *Historical-Critical Dictionary*, part 4, from Seb to Z, col. 1582. ↩

16. Georg Lamprecht, *Lehrbuch der Technologie oder Anleitung zur Kenntniß der Handwerke, Fabriken und Manufacturen*. Halle: in der Hemmerdeschen Buchhandlung, 1787. Compared to Beckmann, relatively little has been written on Lamprecht, whose professional title at Halle was Professor der Rechte und Philosophie; he is referred to by a (near) contemporary as “the first who,

through his draft of an encyclopedia and methodology of economical, political, and cameral sciences for use in academic lectures…sought to remedy a gap." Georg Gottfried Strelin, *Versuch einer Geschichte und Literatur der Staatswissenschaft* (Erlangen: Johann Jakob Palm und Ernst Enke, 1827), 49. ↩

17. Beckmann, "Vorrede," 6. ↩

18. On Beckmann's relationship to Linné, see Hans-Peter Müller, "Johann Beckmann und Carl von Linné – Anmerkungen zu einer prägenden Begegnung" in *Johann Beckmann (1739-18011). Beiträge zu Leben, Werk und Wirkung des Begründers der Allgemeinen Technologie*. Eds. Günter Bayerl and Jürgen Beckmann. Münster: Waxmann, 1999. ↩

19. Beckmann, "Vorrede," 6. ↩

20. Lamprecht, *Lehrbuch der Technologie*, 10. ↩

21. Beckmann, *Instruction Book on Technology* >(2nd edition), 441-2. ↩

22. Beckmann, *Instruction Book on Technology* (2nd edition), 94-92. ↩

23. According to John Robertson, Genovesi is better known for "a broader conception of political economy, its intellectual scope and practical utility" than for his "technical originality per se (Robertson, "Antonio Genovesi, 335). ↩

24. Abbé Genovesi, *Delle Lezioni di Commercio o sia D'Economia Civile* (Milan: Federico Agnelli, 1768), 80. ↩

25. Abbé Genovesi, *Delle Lezioni*, 80. ↩

26. This initiative is part of what Robertson describes, in the context of Genovesi's *Discorso sopra il vero fine delle lettere e delle scienze*, a "programme of economic, social and moral reform through an education based on science and experience rather than metaphysics" (Robertson, "Antonio Genovesi," 337). ↩

27. August Witzmann, *Des Abts Anton Genovesi, Grundsätze der bürgerlichen Oekonomie. Nach der neuesten und verbesserten Ausgabe aus dem Italienischen übersetzt*, vol. 1 (Leipzig. Paul Gotthelf Kummer, 1776), 107-8. ↩

28. Hermann, *Über die Einführung des Studiums der Technologie*, 3. ↩

29. Hermann, *Über die Einführung des Studiums der Technologie*, 22. ↩

30. Hermann, *Über die Einführung des Studiums der Technologie*, 22. ↩

31. Hermann, *Über die Einführung des Studiums der Technologie*, 57. ↩

32. Hermann, *Über die Einführung des Studiums der Technologie*, 59. ↩

33. Hermann, *Über die Einführung des Studiums der Technologie*, 59. ↩

34. Hermann, *Über die Einführung des Studiums der Technologie*, 70. ↩

Image: "Intereactions," (Screenshots) by Eric Schmaltz with Kevin McPhee and Graeme Ring (2017).